DESCRIPTION

RADIO COMMUNICATION APPARATUS AND RADIO TRANSMISSION
METHOD

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Technical Field

The present invention relates to a radio
communication apparatus and radio transmission method
of a multicarrier transmission system.

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Background Art

Heretofore, in multicarrier transmission systems,
a radio communication system has been proposed whereby
subcarriers are divided into blocks and adaptive

15 modulation is performed for each grouped plurality of
subcarriers. With this kind of system, by performing
adaptive modulation for each block composed of a plurality
of subcarriers rather than on a subcarrier-by-subcarrier
basis, feedback information (SNR or similar channel

20 quality information) from a receiving apparatus can be
provided in block units, as compared with the case where
adaptive modulation is performed on a
subcarrier-by-subcarrier basis, and feedback
information can be reduced proportionally.

25 Also, when adaptive modulation parameters
(modulation scheme and coding scheme) are reported to
a receiving apparatus, it is not necessary to report the
modulation scheme and coding scheme of all subcarriers,

but instead this information can be reported on a block-by-block basis, enabling the control channel transmission rate to be lowered.

With this kind of radio communication system, the
5   size (frequency band) of a block is fixed so as to be a value at which channel fluctuations within each block can be regarded as constant, and system operation is carried out using this fixed block size (see, for example, the document "Frame Configuration and Control Scheme in
10   MC-CDM Systems with Frequency Scheduling," Hara et al, Technical Report OF IEICE, RCS2002-130,pp.67-72, July 2002).

With the conventional radio communication system shown in the above documentation, it is assumed that
15   channel fluctuation within a block (segment) is constant. However, in an actual radio communication system, as the delay time of a delayed waveform increases, so does the amount of intra-block channel fluctuation, and there are cases where the assumption of regarding intra-block
20   channel fluctuation as constant does not hold. Also, even in cases where there is a delayed waveform with a long delay time, if an attempt is made to make intra-block channel fluctuation constant, the block size must be made smaller, and when this is done, there is a problem in
25   that it becomes difficult to sufficiently reduce the amount of information necessary for a control channel even if subcarriers are blocked.

FIG.1 is a schematic diagram showing an example of

conventional block assignment. When the block size (number of subcarriers in a block) is fixed as in the example of the conventional art shown in FIG.1, due to the occurrence of a state in which a plurality of blocks

5   are assigned successively on the frequency axis to the same user C, the number of blocks may become unnecessarily large for the actual propagation environment. In this case, there is a problem of the amount of control information becoming unnecessarily large due to the fact

10   that control information (modulation scheme, coding scheme, and so forth) is transmitted to the receiving apparatus on a block-by-block basis.

Disclosure of Invention

15   It is an object of the present invention to provide a radio transmitting apparatus and radio transmission method that improve system throughput.

    In order to achieve this object, with the present invention, the block size (number of subcarriers) is

20   varied adaptively for each receiving station in a multicarrier communication system.

Brief Description of Drawings

    FIG.1 is a schematic diagram provided to explain

25   conventional assignment within blocks;

    FIG.2 is a block diagram showing the configuration of a radio communication system according to an embodiment of the present invention;

FIG.3 is a block diagram showing the configuration of a transmitting apparatus according to an embodiment of the present invention;

FIG.4 is a block diagram showing the configuration

5   of a receiving apparatus according to an embodiment of the present invention;

FIG.5A is a characteristic curve diagram showing received wave delay time distribution according to an embodiment of the present invention;

10   FIG.5B is a characteristic curve diagram showing received wave delay time distribution according to an embodiment of the present invention;

FIG.5C is a characteristic curve diagram showing received wave delay time distribution according to an

15   embodiment of the present invention;

FIG.6 is a characteristic curve diagram showing the relationship between reception power and frequency of a receiving apparatus according to an embodiment of the present invention;

20   FIG.7 is a schematic diagram provided to explain assignment within blocks according to an embodiment of the present invention; and

FIG.8 is a flowchart showing the block assignment processing procedure of a transmitting apparatus

25   according to an embodiment of the present invention.

Best Mode for Carrying out the Invention

With reference now to the accompanying drawings,

an embodiment of the present invention will be explained in detail below.

FIG.2 is a block diagram showing the overall configuration of a radio communication system according to an embodiment of the present invention. As shown in FIG.2, in this radio communication system, a transmitting apparatus 100 performs radio communications with a plurality of receiving apparatuses 200, 300, 400, ... by means of a multicarrier transmission method.

FIG.3 is a block diagram showing the configuration of transmitting apparatus 100. As shown in FIG.3, transmitting apparatus 100 receives transmit data D1 through Dn to be transmitted to receiving apparatuses 200, 300, 400, ... (users #1 through #n) in blocking sections 101-1 through 101-n. Blocking sections 101-1 through 101-n assign the number of subcarriers to be used for transmit data D1 through Dn based on a control signal for controlling the number of subcarriers in a block supplied from an intra-block subcarrier number control section 116, and supply these to a scheduler 102.

Scheduler 102 arranges transmit data D1 through Dn blocked in a plurality of subcarriers on the frequency axis, and supplies them to adaptive modulation sections 103-1 to 103-n respectively. Adaptive modulation sections 103-1 to 103-n perform modulation based on the determined modulation M-ary value (modulation level) for each user supplied from a modulation control section 115, and supply the results to an IFFT (Inverse Fast Fourier

Transform) processing section 104.

IFFT processing section 104 generates an OFDM signal (multicarrier signal) by superimposition of the respective transmit data subcarriers, and supplies this

5 signal to a GI (Guard Interval) adding section 105. GI adding section 105 adds a guard interval to the OFDM signal, and then supplies the resulting signal to a transmitting RF (Radio Frequency) section 106. Transmitting RF section 106 performs predetermined radio transmission

10 processing (such as D/A conversion and up-conversion, for example) on the signal following guard interval insertion, and transmits the signal resulting from this radio transmission processing as a radio signal via an antenna 107.

15 A received signal received by a receiving RF section 111 via antenna 107 undergoes predetermined radio reception processing (such as down-conversion and A/D conversion, for example) in this section. Receiving RF section 111 supplies signals resulting from this radio

20 reception processing to a number of channel estimation value and maximum delay time receiving sections 112-1 through 112-n equivalent to the number of users.

Channel estimation value and maximum delay time receiving sections 112-1 through 112-n extract a channel

25 estimation value and maximum delay time from the received signal for each user, and supply these to modulation control section 115, scheduler 102, and intra-block subcarrier number control section 116. Modulation

control section 115 performs adaptive modulation control on a block-by-block basis based on a reception power value or SNR or other channel quality information transmitted as channel estimation values from receiving apparatuses

5   200, 300, and 400. Intra-block subcarrier number control section 116 determines the block size (number of subcarriers) for each receiving apparatus based on the maximum delay time for each receiving apparatus. Scheduler 102 selects the receiving apparatus with the

10   best propagation environment in each band on the frequency axis based on channel estimation values from the receiving apparatuses, and performs arrangement of blocks on the frequency axis by assigning the block of that receiving apparatus to that receiving apparatus (user).

15   In transmitting apparatus 100, block-by-block information relating to the subcarrier modulation scheme and coding scheme, block size (number of subcarriers), and block arrangement on the frequency axis, is transmitted on a block-by-block basis by means of a control

20   channel.

         FIG.4 is a block diagram showing the configuration of a receiving apparatus 200. A receiving RF section 202 performs predetermined radio reception processing such as down-conversion and A/D conversion on a received signal

25   received via an antenna 201, and then supplies the resulting signal to a GI removing section 203 and maximum delay time measurement section 207.

         GI removing section 203 removes guard intervals

inserted in the signal that has undergone radio reception processing, and supplies a signal with guard intervals removed to an FFT (Fast Fourier Transform) processing section 204. FFT processing section 204 performs

5 serial/parallel (S/P) conversion on the signal with guard intervals removed, performs FFT processing on the signal resulting from S/P conversion and performs conversion to per-subcarrier information, and supplies pilot symbols, which are known signals within these signals that have

10 undergone FFT processing, to a channel estimation section 208 on a subcarrier-by-subcarrier basis.

Channel estimation section 208 performs channel estimation on a subcarrier-by-subcarrier basis using the pilot symbols of each subcarrier, and outputs the obtained

15 per-subcarrier channel estimation values to a channel compensation section 209.

Channel compensation section 209 multiplies the post-FFT-processing subcarrier signals by the channel estimation values of the respective subcarriers by means

20 of multipliers 205-1 through 205-n, and performs channel compensation for the post-FFT-processing subcarrier signals. Channel-compensated subcarrier signals are output to a data extraction section 206 where their receive data is extracted.

25 Maximum delay time measurement section 207 estimation values the maximum delay time from a delay profile of a received signal, and supplies the result to a feedback information generation section 210.

Feedback information generation section 210 generates feedback information from maximum delay time information supplied from maximum delay time measurement section 207 and channel estimation values for the number of subcarriers supplied from channel estimation section 208, and supplies this feedback information to a transmitting RF section 211. Transmitting RF section 211 performs transmission processing such as up-conversion and D/A conversion on the feedback information, and transmits a signal that has undergone this transmission processing via antenna 201. In a radio communication system of this embodiment, through the use of FDD (Frequency Division Duplex), maximum delay time is measured on the receiving apparatus side and this is feed back to transmitting apparatus 100, but in a system that uses TDD (Time Division Duplex), the delay profile of a signal from a receiving apparatus may be measured on the transmitting apparatus side.

Processing for assigning a number of intra-block subcarriers to receiving apparatuses 200, 300, 400, ... using the above configurations will now be described. FIG.5A, FIG.5B, and FIG.5C are characteristic curve diagrams showing maximum delay times in receiving apparatuses 200, 300, and 400.

As shown in FIG.5A, FIG.5B, and FIG.5C, the maximum delay time of receiving apparatus 200 is designated τA (seconds), the maximum delay time of receiving apparatus 300 is designated τB (seconds), and the maximum delay

time of receiving apparatus 400 is designated τC (seconds).

As the delay time increases, the fluctuation period on the frequency axis becomes shorter and fluctuation

5 becomes more intense. Therefore, intra-block subcarrier number control section 116 of this embodiment reduces the number of subcarriers assigned and reduces the block size for a receiving apparatus that has a long maximum delay time, and conversely, increases the number

10 of subcarriers assigned and increases the block size for a receiving apparatus that has a short maximum delay time.

By this means, as shown in FIG.6, for example, in the case of frequency-power relationship C of receiving apparatus 400 that has a short maximum delay time, the

15 fluctuation period is increased, whereas in the case of frequency-power relationship A of receiving apparatus 200 that has the longest maximum delay time, the fluctuation period becomes the shortest. Also, in a propagation environment in which the maximum delay time

20 is τ, channel fluctuation on the frequency axis has a frequency component of only $1/\tau$ [Hz] or less.

Therefore, in such a case, as shown in FIG.7, intra-block subcarrier number control section 116 finds frequency assignments $1/(\tau A)$, $1/(\tau B)$, and $1/(\tau C)$ from

25 maximum delay times τA, τB, and τC of receiving apparatuses 200, 300, and 400, and determines the number of subcarriers of each block from these values. Then assignment on the frequency axis is performed as shown in FIG.7 by scheduler

102.

By this means, the longer the maximum delay time (the greater the propagation path fluctuation on the frequency axis) of a receiving apparatus, the smaller

5 is the number of assigned intra-block subcarriers, and the shorter the maximum delay time (the smaller the propagation path fluctuation on the frequency axis) of a receiving apparatus, the greater is the number of assigned intra-block subcarriers. Therefore, if, for

10 example, eight blocks are necessary when the block size is fixed as in the example of the conventional art shown in FIG.1, with this embodiment six blocks are sufficient on the basis of a particular propagation environment. As a result, it is possible to reduce the amount of control

15 information (the number of adaptive modulation parameters and so forth) required to be transmitted using a control channel for each block.

FIG.8 is a flowchart showing the control processing procedure in intra-block subcarrier number control

20 section 116 of transmitting apparatus 100. As shown in FIG.8, intra-block subcarrier number control section 116 obtains propagation environment information (maximum delay times) for each receiving apparatus from channel estimation value and maximum delay time receiving

25 sections 112-1 through 112-n in step ST101, and then proceeds to step ST102 and determines the number of subcarriers per block based on this propagation environment information. In this case, the smallest

number of subcarriers such that intra-block channel fluctuation becomes constant is determined. Specifically, if the subcarrier bandwidth is designated W [Hz], by determining the number of subcarriers per block

5   so as to be W×τmax [subcarriers] for maximum delay time τmax, the smallest number of subcarriers such that intra-block channel fluctuation becomes constant can be selected.

The number of subcarriers of each block determined

10   by intra-block subcarrier number control section 116 in this way are assigned by blocking sections 101-1 through 101-n. The blocks are then arranged on the frequency axis by the scheduler 102. In this case, scheduler 102 finds the relationships between reception power and frequency

15   shown in FIG.6 based on feedback information (channel estimation values) obtained from receiving apparatuses 200, 300, and 400 respectively, and performs block arrangement based on these relationships.

Thus, according to transmitting apparatus 100 of

20   this embodiment, by enabling a number of subcarriers to be determined for each of a plurality of receiving stations (receiving apparatuses 200, 300, 400, ...), it is possible to eliminate unnecessary subcarrier assignment, and also to decrease the amount of control channel information

25   and reduce interference with other cells. Also, by determining the number of subcarriers per block in accordance with the maximum delayed waveform delay time of a received signal received by a receiving apparatus,

it is possible to select a number of subcarriers appropriate for the propagation environment. Furthermore, if the subcarrier bandwidth is designated W [Hz], by determining the number of subcarriers per block

5 so as to be W×τmax [subcarriers] for maximum delay time τmax, it is possible to select the smallest number of subcarriers such that intra-block channel fluctuation becomes constant, and as a result, a sufficient necessary number of subcarriers can be selected.

10 A transmitting apparatus and receiving apparatus according to this embodiment are suitable for provision in a radio communication terminal apparatus and radio communication base station apparatus used in a mobile communication system.

15 As described above, according to the present invention, by dividing subcarriers into blocks, selecting a receiving station on a block unit basis, and adaptively varying the number of subcarriers per block for each receiving station based on the propagation environment

20 of that receiving station, it is possible to determine the number of subcarriers for each of a plurality of receiving stations, and to eliminate unnecessary subcarrier assignment. It is thus possible to improve system throughput.

25 This application is based on Japanese Patent Application No.2002-372928 filed on December 24, 2002, the entire content of which is expressly incorporated by reference herein.

Industrial Applicability

The present invention is applicable to a radio communication terminal apparatus and radio communication base station apparatus used in a mobile communication system.